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Lubrication

A Technical Publication Devoted to
the Selection and Use of Lubricants

THIS ISSUE

Oil Purification,
Filtration
and Reclamation



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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Oil Purification, Filtration and Reclamation

EXTENDING the useful life of lubricating oil has been and continues to remain an important part of good equipment maintenance. While methods of oil purification, filtration or reclamation will assist materially in prolonging the useful life of lubricating oil, a more important requirement is proper application of the right type of lubricating oil to a given piece of equipment. Supplementing this, and equally important, is the necessity for operating and maintaining equipment in accordance with the instructions issued by the manufacturer. If the right type of lubricating oil is applied to equipment which is properly operated and maintained, the oil will provide satisfactory performance for relatively long periods of service before replacement of the oil is desirable.

Even though lubricating oil is accorded good treatment through proper operation and maintenance of equipment, it nevertheless deteriorates and/or becomes contaminated after extended periods of use. This is dependent, of course, upon the type and severity of service. The method used for purification,

filtration or reclamation of the used oil and whether this should be done during operation or after removal of the oil from the system, require individual consideration, since obviously the cost of oil life extension must not exceed the value of the amount of new oil to be purchased if one of the methods is not used. The following discussion is presented to assist the operator of equipment to better evaluate his own particular problems of lubrication.

CLEAN OIL IS BETTER OIL

There is a definite relationship between effective lubrication and oil purification, filtration or reclamation. Clean oil throughout the period of its useful life logically is good insurance that dependable lubrication will result. Development of the means and methods to accomplish this objective has been one of the outstanding contributions to successful mechanized production and transportation.

Keeping lubricating oil clean was a logical development along with flood lubrication. Both accompanied the perfection of the steam turbine and internal combustion engine; both soon went beyond those primary fields of power generation in their applicability to machine tools and heavy duty production machinery as, for example in the steel and paper industries.

In addition to protecting lubrication, proper reconditioning of lubricating oils also has a marked psychological effect upon engine or machinery operators. It is a real contribution to more economical maintenance. The elimination of worry and mental strain is a decided asset.

CHARACTERISTICS OF USED OILS

Used oils are characterized by one or more of the following conditions:

1. Oil which has deteriorated due to oxidation in the presence of air or other oxygen-containing media, accompanied by high temperature service. Products of oxidation may be soluble or insoluble in the used oil depending upon the degree of deterioration.
2. Oil which has deteriorated due to polymerization (linkage of unsaturated oil molecules to form progressively heavier molecules causing

oil thickening), a result of high as well as normal temperature service. Products of polymerization may be soluble or insoluble in the used oil.

3. Oil which has been contaminated with extraneous matter. Products of contamination include:
 - (a) Dirt and dust common to region in which equipment operates.
 - (b) Core sand that has remained in metal castings from the time they were formed in the foundry.
 - (c) Metal particles from the time equipment was in the machine or repair shop.
 - (d) Metal particles due to disintegration or wearing of parts such as bearings, piston rings, etc.
 - (e) Carbon and other products of partial decomposition or oxidation resulting from destruction of oil or incomplete combustion of fuel.
 - (f) Water and anti-freeze.
 - (g) Dilution with fuels.
 - (h) Miscellaneous, such as paint, asbestos, linseed oil, etc.

If used oils are to be continued in service, the products of oxidation and polymerization and any foreign contaminants should be removed. There are many ways of removing such materials from oil, but all fall into three basic types of equipment:

1. Gravity purification methods, such as gravity settling and centrifuging, which are capable of removing only insoluble materials.
2. Filtering equipment which can remove insoluble matter and some soluble products depending on type of media.
3. Reclaiming methods which not only can remove insoluble materials, but are also capable of removing varying amounts of soluble products depending upon equipment design and operating conditions.

GRAVITY PURIFICATION OF LUBRICATING OIL

Methods for gravity purification of lubricating oils include simple gravity settling followed by decantation and/or treatment by centrifuging either wet or dry.

Settling Followed by Decantation

The simplest means of effecting some degree of

purification of used lubricating oil is to permit the oil to rest in a settling tank for a period of time. During this time, and depending on temperature and efficiency of settling and decanting facilities, it is generally possible to remove the major part of the suspended insoluble oxidized material, foreign particles, dirt and water. Separation of such oil contaminants is made by gravity alone, and is adversely affected if stable emulsions exist.

Settling is most effective in horizontal tanks with vee shaped or sloped bottoms and having either jacketed walls or steam coils for heating the oil to proper temperature. Depending on oil viscosity, best results are obtained at oil temperatures of 120-160° F. Obviously, excessive temperatures should be avoided to prevent the acceleration of oil oxidation. It is to be noted that practically no settling will occur while the oil is being heated because of the convection currents created. Also, settling at low temperatures should be avoided because the rate of separation is slowed up due to the higher viscosity of the oil.

Disadvantages of purifying oil by settling and decantation are as follows (assuming equipment for which oil is required has to operate continuously):

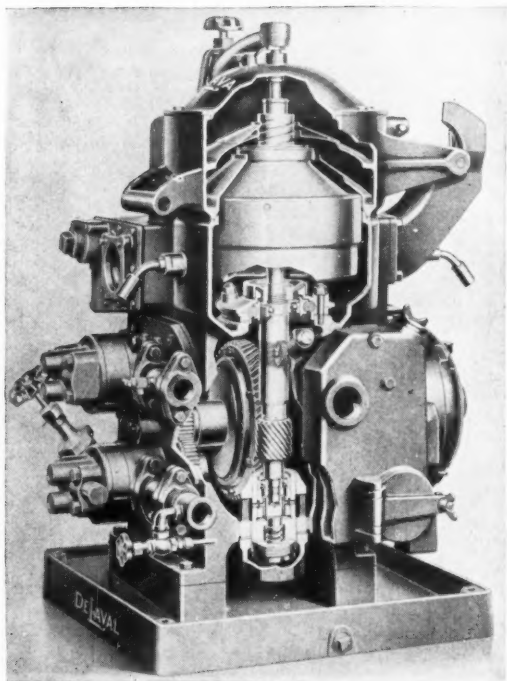
1. Two complete batches of oil are required.
2. It is generally necessary to shut the machine down to change the oil.
3. Considerable space is required for settling tanks.
4. At least ten days are usually required for satisfactory clarification.
5. While oil is in service, impurities are not removed as they collect, but are permitted to build up to some predetermined concentration at which time the batch is withdrawn and purified.
6. Purification is not complete. Those insolubles which are close in gravity to that of the oil cannot be removed by this process.

Purification by this method is adaptable to all straight mineral oils such as those used for lubricating diesel and gas engines, air and refrigerating compressors, steam turbines and general plant equipment. It is important to realize that oils so handled are only partially clarified. They may still contain soluble oxidation and polymerization products as well as amounts of fuel dilution, depending on the type of service involved. Future use of purified oil will depend mainly on the length of service the oils have already undergone and their extent of oxidation and dilution. Heavy-duty, additive-type oils cannot be purified by this method with any

COMPARISON OF PURIFICATION, FILTRATION AND RECLAMATION METHODS

	GRAVITY PURIFICATION			FILTRATION			RECLAMATION	
	Gravity Settling	Centrifuging Dry	Wet	Mechanical Filters	Absorption Filters	Adsorption Filters	Clay-Type Reclaimers	Chemical Treatment
Filtering Media	Inactive	Inactive	Active	Active	Active
Application to Systems								
Full-Flow	No	No	No	Yes	Not generally	Not generally	No	No
By-Pass	No	Yes	Yes	Yes	Yes	Yes	Sometimes	No
Batch	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contaminants Removed								
Insoluble Solids								
Large particle size	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Small particle size	No	Some ⁽¹⁾	Most	No	Yes	Yes	Yes	Yes
Insoluble Oxidation Products								
Agglomerated	Some	Most	Yes	Some ⁽²⁾	Yes	Yes	Yes	Yes
Dispersed	No	No	Some	No	Some	Yes	Yes	Yes
Soluble Oxidation Products	No	No	No	No	No	Most ⁽³⁾	Yes	Yes
Water & Water Soluble Materials	Yes	Yes	Yes	No	Some	Some	Yes	Yes
Removal of Oil Additives	No	No	Some ⁽¹⁾	No	No	Some ⁽⁵⁾	Yes	Yes

⁽¹⁾ Providing gravity heavier than oil⁽³⁾ Depending upon type of media⁽²⁾ Depending upon size of agglomerates⁽⁵⁾ Depending upon type of additive⁽⁴⁾ Only those which are water sensitive



Courtesy of The De Laval Separator Company

Figure 1—Sectional view of the De Laval "Uni-Matic" Oil Purifier.

degree of success because of their dispersion characteristic. This property prevents agglomeration of insoluble contaminants with the result that settling of these materials is all but impossible.

Treatment by Centrifuging

Purification by centrifuging employs the same basic principle as settling and decantation, but is faster and more complete because the separating force is several thousand times that of gravity. The centrifuge or centrifugal separator is a device for freeing the oil of suspended insoluble oxidized material, foreign mineral and carbonaceous matter, dirt and water. Claims are made that centrifuging an oil will also remove soluble oxidation products. This is generally not true, except in the case of some organic acids (only those more soluble in water than oil) which may be removed if water is added along with the oil being centrifuged. This is also true for mineral acids if present. Centrifuging wet, if started on new oil, will keep the accumulation of acids in the oil at a very low level. As with settling and decantation, a centrifuge will not separate liquids which are mutually soluble, such as fuel in lubricating oil. Likewise this method of purification will not remove colloidal foreign matter, particularly from heavy-duty engine oils with dispersant properties.

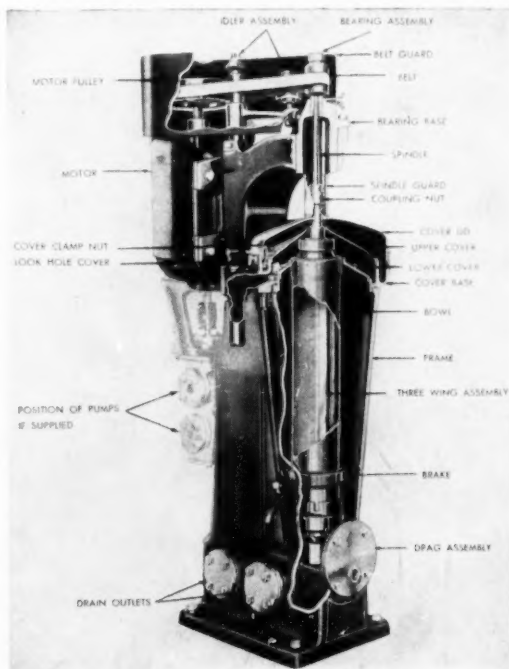
The term "capacity," as applied to centrifuges,

is often used loosely. A centrifuge may be said to have two capacities:

1. Through-put capacity, which is the total quantity of oil that may be put through the machine without overflowing regardless of the degree of purification effected.
2. Effective capacity, which is the quantity of oil that may be put through the machine with the desired degree of purification.

Effective capacity generally has no relation to through-put capacity but is of major consideration to the user. Effective capacity depends upon used oil viscosity, oil temperature in the centrifuge, degree of oil contamination, degree of purification desired, and persistency of emulsion if water is present. In selecting a centrifuge for use on a bypass in a circulating system, it is best to choose one having a manufacturer's rated capacity sufficient to handle all of the oil in the system in some three to six hours. This is based on the assumption the centrifuge will be operated either continuously or intermittently on oil batches.

When centrifuges are used for oil purification, they should always be set to operate by the two-liquid discharge method. This does not necessarily mean that water should be added to the centrifuge, but a discharge opening should be provided to emit



Courtesy of The Sharples Corporation

Figure 2—Details of the Sharples Super-Centrifuge with parts identified.

LUBRICATION

any water which may get into the oil system. This is particularly necessary:

1. In all marine turbine and diesel installations.
2. In land turbine installations.
3. When condensation is apt to occur, as when operating a diesel or gas engine intermittently or with a crankcase sufficiently cold to condense the water vapor present in blow-by gases.
4. When oil storage tanks are buried in the ground.

The terms "wet" or "dry" centrifuging are used to indicate whether or not water is intentionally added to the oil at the centrifuge. Although it is somewhat inconvenient, cleaner oil will result by the addition of water to the oil at the centrifuge under proper operating conditions. Care must be taken to be sure stable emulsions are not formed as a result of introducing water at the centrifuge. Centrifuging wet has the following advantages:

1. The water has a washing effect, aiding in the removal of impurities.
2. The water carries away most of the lighter insoluble impurities which have gravities approximately the same as that of oil, permitting longer runs between cleanings.
3. Some acids, particularly when freshly formed in lubricating oil, are more soluble in water than in oil and are thus removed, as are mineral acids.
4. In many cases of corrosion of centrifuge bowl parts in service the corrosive attack has been markedly diminished, or entirely stopped, by feeding a small amount of fresh clean water, continuously into the centrifuge, thus diluting and washing out salt and acidic contaminants. This is particularly true for marine turbine and diesel installations.

The objections to wet centrifuging are:

1. Due to the greater density of water, the water discharge must be of a greater diameter than the oil discharge to permit water to flow out of the centrifuge. Accordingly, if the water seal breaks, oil will flow out of the lower discharge instead of the oil discharge.
2. If periodic cleaning of the centrifuge is neglected, the dirt-holding space may become filled with oil contaminants and water. When this occurs the bowl overflows and dirt and water are not removed from the oil.
3. Clean oil and water will not normally emulsify. If the oil becomes unusually dirty, emulsion difficulties may occur. In such cases the amount of water should be decreased, the oil temperature increased, or the oil feed rate temporarily reduced until satisfactory separation is

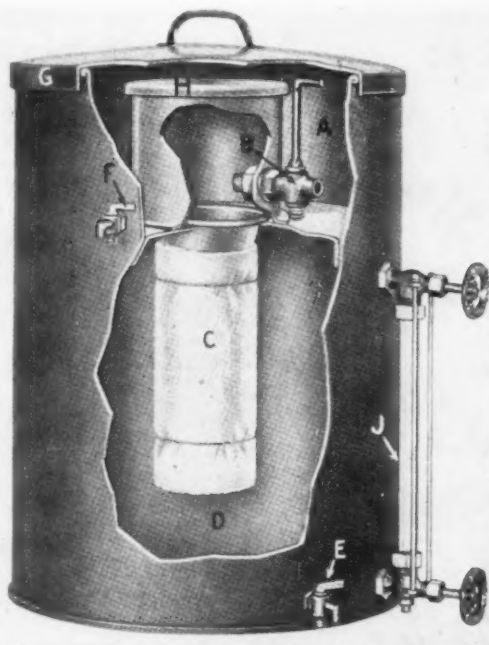
again obtained. Normally a centrifuge will break an emulsion which is not too stable.

4. Certain types of additives used in heavy-duty diesel engine oils and in inhibited turbine oils tend to concentrate at an oil-water interface with the result that at least a portion of such additives will be removed.

The results of purifying used lubricating oils by centrifuging are the same as those accomplished by settling and decantation, but in a more efficient and less time-consuming manner.

LUBRICATING OIL FILTRATION

Oil filters are of many types and when used are almost always installed in connection with the equipment being lubricated. Such filters are generally used in the forced-feed lubricating systems of



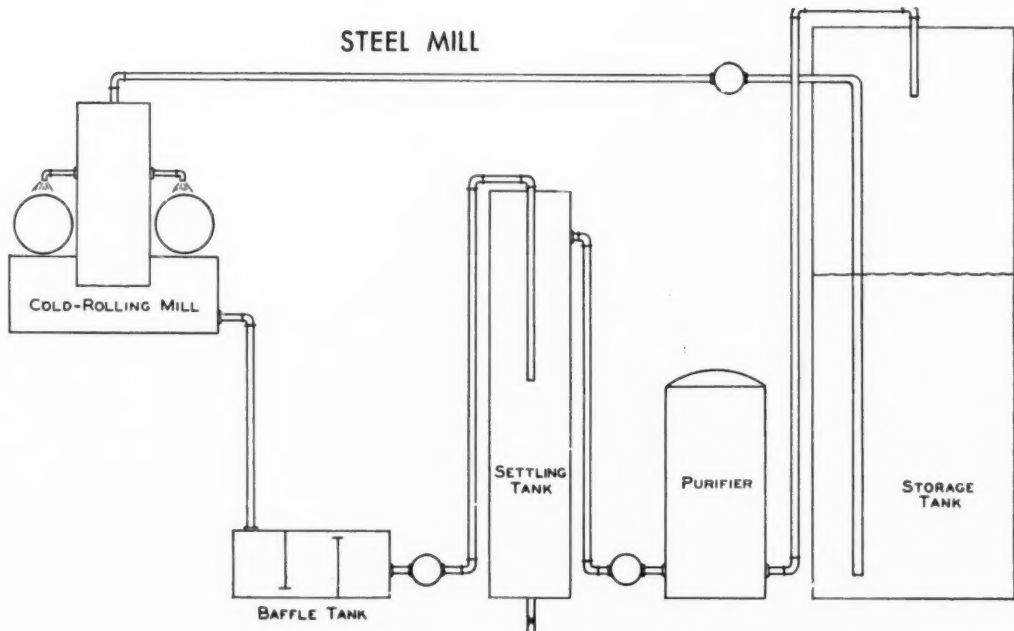
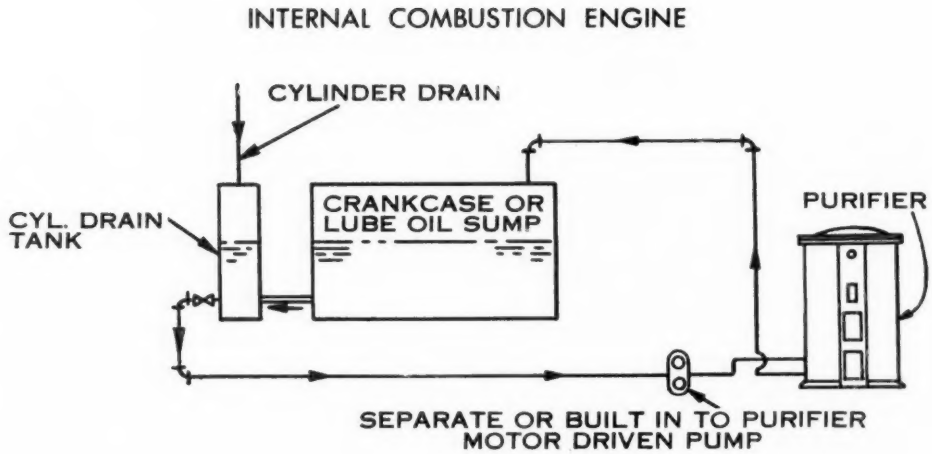
Courtesy of Bowser Incorporated

Figure 3—The Bowser Batch Filter especially designed as a portable unit. A is the settling compartment; B is the adjustable inlet control valve; C is the filtering cylinder; D is the clean oil storage compartment; E and F are draw-off cocks; G and H are covers; J is the sight glass.

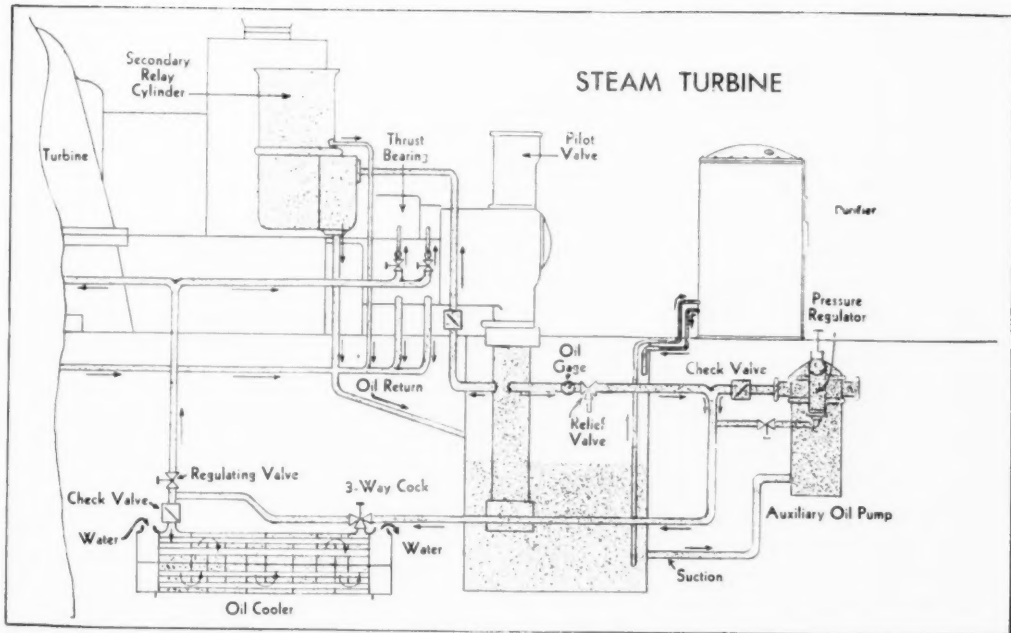
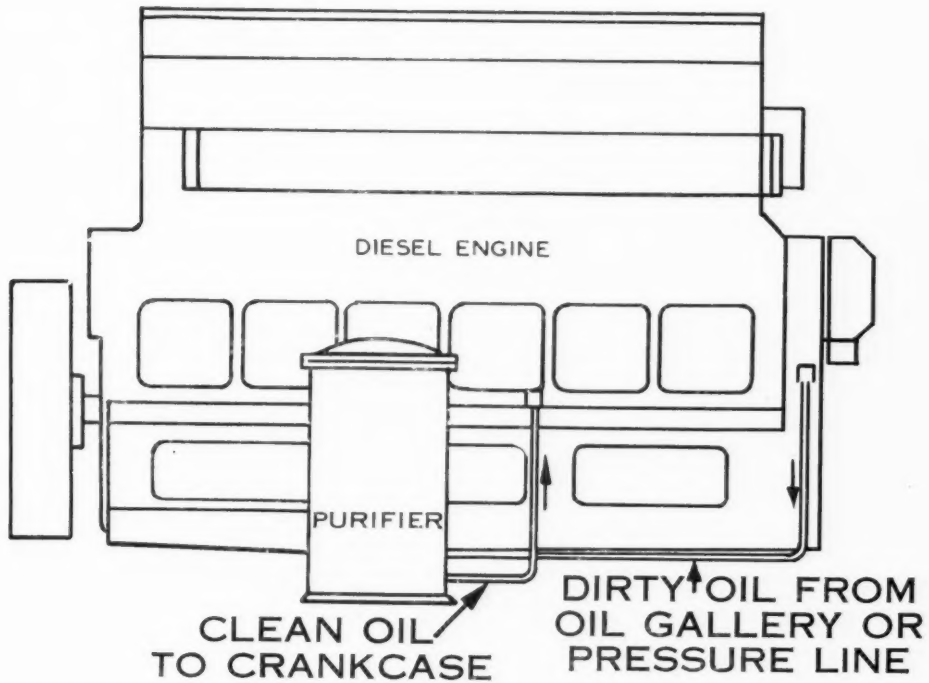
internal combustion engines regardless of the type of service. Gas, gasoline, tractor and diesel engines fall in this category.

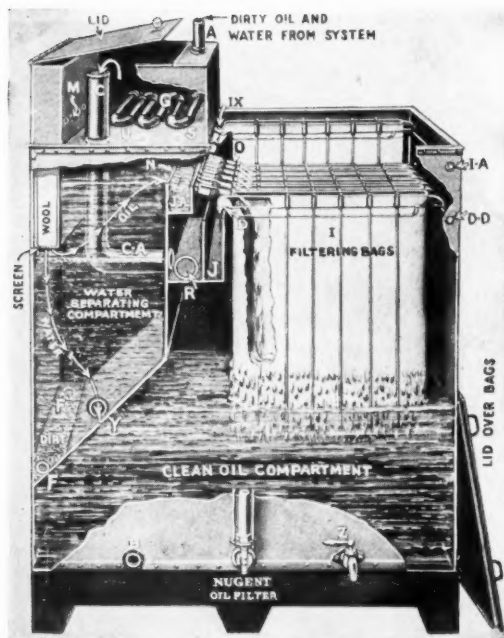
Oil filters under this heading are composed of housings in which removable elements or cells may be placed. When elements become partially clogged with oil contaminants, they can either be removed and cleaned or replaced with new elements, depending on type. Such an installation makes for

TYPICAL LUBRICATING OIL REC



RECONDITIONING SYSTEMS





Courtesy of Wm. W. Nugent & Co., Inc.

Figure 4—Details of the Nugent Oil Filter showing relative location of component parts and direction of oil flow.

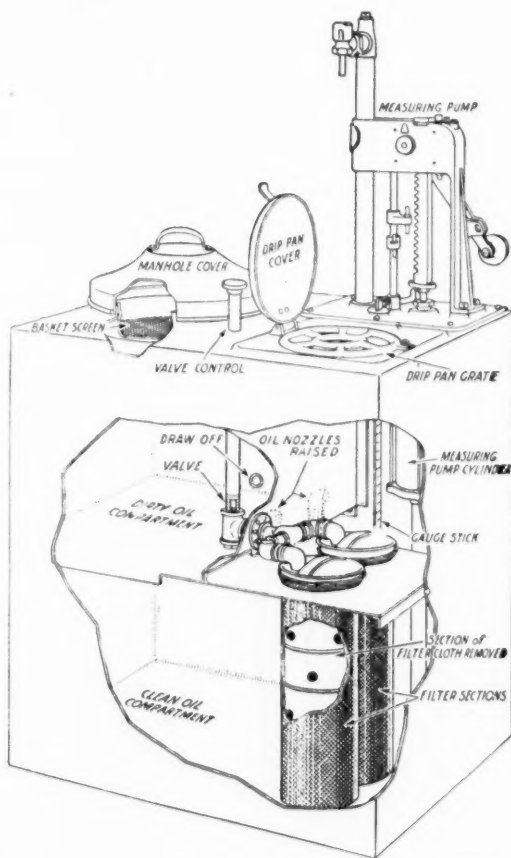
simplicity in maintaining reasonably satisfactory oil performance. There is another type of oil filter composed of a housing and element in one unit. When this type becomes clogged, it is necessary to replace the whole assembly.

Depending on the kind, oil filters are capable of removing insoluble oxidized material, foreign mineral and metal particles, carbonaceous matter, water and dirt, and in certain cases some soluble oxidation products. Oil filters will not separate mutually soluble liquids, such as diluent or fuel from lubricating oil. Types of oil filters may be classified as follows:

1. Metallic or mechanical (edge-type, copper ribbon, steel wool, screen, strainer). Filters of this type remove coarse contaminants such as metal chips and particles of grit and scale by means of closely woven metal screens. Removal of insoluble oxidized material is generally not effected unless the size of such particles is sufficiently large to be caught by the filter element openings. Soluble oxidized material, finely divided carbon particles, water, dust and finer insoluble oxidation products cannot be removed by such filters.
2. Absorbent (cotton waste, wood pulp, wound yarn, felt, flannel, cloth, paper, mineral wool, quartz, diatomaceous earth, asbestos). Filters of this type not only remove coarse contami-

nants but also aid in the removal of finer insoluble particles such as carbon, dust and insoluble oxidized material. Certain of these filters remove mineral acids as well as water. Soluble oxidation products are not removed. Filtration is accomplished by adhesion of contaminants to element structures, and absorption by the components of the filter due to porosity.

3. Adsorbent (Fuller's earth, boneblack, charcoal, other active type clays—chemically treated paper and waste). In addition to removing coarse and fine contaminants, filters of this type are capable of reducing the amounts of soluble oxidized material and water to a limited extent. Such filters remove oil contaminants not only by mechanical means, but also as a result of chemical action and adsorption. Adsorbent filters may remove chemical additives blended with certain oils to improve performance characteristics, but this is not true in all cases.



Courtesy of Bowser Incorporated

Figure 5—The Bowser type "B" combination oil filter and storage tank. This unit is especially suited for batch filtration of crankcase oils from power plant machinery, compressors and small turbines.

LUBRICATION

Oil filters may be installed in either of the following ways:

1. Full flow: One receiving total oil supply from pump discharge. Metallic or mechanical type filters are generally used for this purpose.
2. By-pass: One receiving only a portion of the oil circulating in the system. Absorbent and adsorbent type filters are generally used for this purpose.

It should be pointed out that practically all types of filters are equipped with means of by-passing the oil when filter clogging occurs. Oil filtration is almost always employed in conjunction with internal combustion engine installations and is also used to some extent in connection with other equipment. For instance, filters of the absorbent or adsorbent types are sometimes used to supplement methods of oil purification (batch or centrifuge) in turbine installations. Where large oil storage facilities are available, metallic or mechanical type filters are generally used in the lines between tanks and equipment to be lubricated. Oil filters may be used in any lubricating system where sufficient pressure is available to force the oil through the filtering medium.

LUBRICATING OIL RECLAMATION

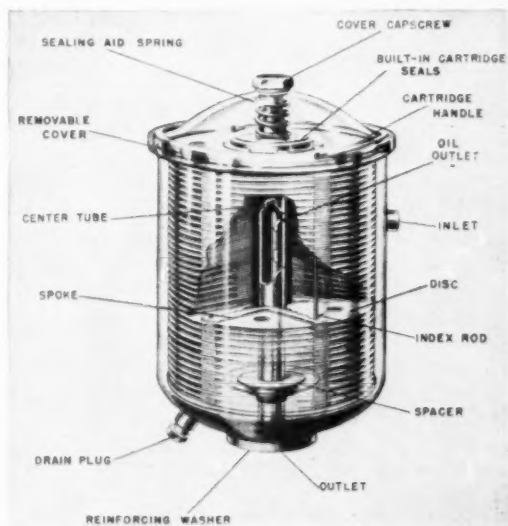
Used lubricating oils can be reclaimed or re-refined by a variety of methods, the more important of which are described in the following:

High Temperature Clay-Type Oil Reclaimers

In the high temperature clay-type oil reclaimer oil is purified by contact with Fuller's earth or similar activated clays. This can be done in batch or by continuous treatment. These reclaimers remove most of the solids present in used lubricating oil such as mineral matter, dirt and carbonaceous material. Soluble oxidation products, which are responsible for varnish and lacquer formations on hot engine surfaces, are reduced to an extent varying with clay efficiency, clay to oil ratio and operating conditions. This reclaiming method also reduces the amounts of water and organic acidity which may be present in the used oil. In this process the oil is often heated to 400° F., and in some reclaimers even higher under vacuum, which means volatile liquids such as gasoline are substantially removed. If used oil is contaminated with diesel fuel, however, only a portion of the fuel can be removed unless the reclaiming temperature is raised considerably above 600° F. Reclaiming at this temperature, however, may volatilize some of the lighter lubricating oil ends which will pass off with the diluent. The recovered oil will then be appreciably higher in vis-

cosity than when new. If reclaimers are operated at temperatures much above 600° F. cracking of the oil will result. High temperature clay reclaimers will also remove most chemical materials which may have been added to lubricants to improve certain performance characteristics. For this reason clay type reclaimers should not be used to reclaim used additive oils unless the reclaimed oil is relegated to some service not requiring heavy-duty or additive type lubricants.

In a typical reclaimer a batch of used oil is placed in a cylindrical tank and heated electrically. Clay may be added and mixed by mechanical agitation prior to high temperature heating or after the oil has reached the proper temperature, usually around 400-425° F. This temperature is an average one for reclaiming used stocks of diesel and gasoline engine crankcase oils. Following the agitation and heating period, which may vary from 15 minutes to an hour's time, the oil and clay mixture is forced by means of compressed air through one or two-stage paper filter presses which remove both clay and impurities. In another type of reclaimer the oil is pumped over a hot surface (electrically heated)

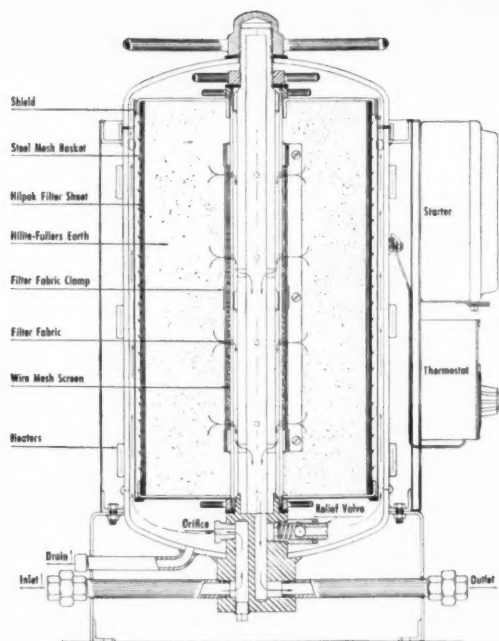


Courtesy of Fram Corporation

Figure 6—Constructional details of the Fram Filcron Filter.

which drives off water and fuel diluents. The hot oil is then passed through a bed of clay and a layer of filter paper which removes the remaining contaminants. This process is considerably slower than the one previously discussed. In still a third type of reclaimer employing contact filtration, a continual draft of air is blown over the oil being heated and mixed with clay. This aids in removing fuel dilution by hastening evaporation.

There is no limit to the amount of used oil which



Courtesy of The Hilliard Corporation

Figure 7—The Hilco Type FA-1 Hyflow Oil Filter showing relative arrangement of component parts.

can be reclaimed by this general method, providing several units are in use. If the used oil is in fairly good condition, the amount of oil reclaimed will approximate the maximum rated capacity of the unit. If, on the other hand, the oil is badly contaminated and oxidized, the flow rate may be as low as 50 per cent of the maximum rated capacity. The presence of water or chemical additives in the oil may reduce the flow rate appreciably. The flow rate will also be influenced by the clay to oil ratio. The percentage of oil recovered from the reclaimer will vary from 50 to 95 or more per cent of the oil charged, depending upon reclaimer design, condition of the oil, amount of clay used per gallon of oil, and method of operation.

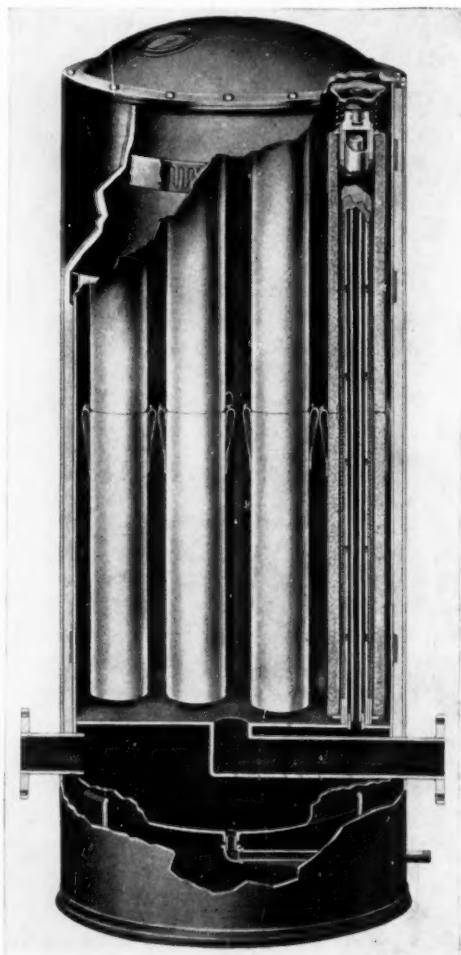
Advantages of using high temperature clay-type reclaimers are:

1. When this process is applied to straight mineral oils, and properly carried out, it is generally possible to produce a reclaimed oil having physical tests approximating those of the original product. This does not imply that reclaimed oil is equivalent to new oil in actual service.
2. While the reclaimed oil is not as satisfactory as the original oil, this is partially compensated for by the fact that where reclaiming units are installed, the oil is generally changed and reclaimed more frequently so that the average oil

condition is maintained at a reasonably good standard. Addition of new oil as make-up also improves the quality of the reclaimed oil.

Disadvantages of this type of process are:

1. Quality of reclaimed oil is not as good as new oil from performance point of view.
2. In small installations where the amount of oil involved is small, or even in larger installations where the oil is not rapidly contaminated or oxidized, the high first cost of the reclaiming equipment may not be justified. Also operating costs, including cost of clay and extra manpower, may not be warranted. In such instances more economical lubrication can be obtained by periodic oil change.

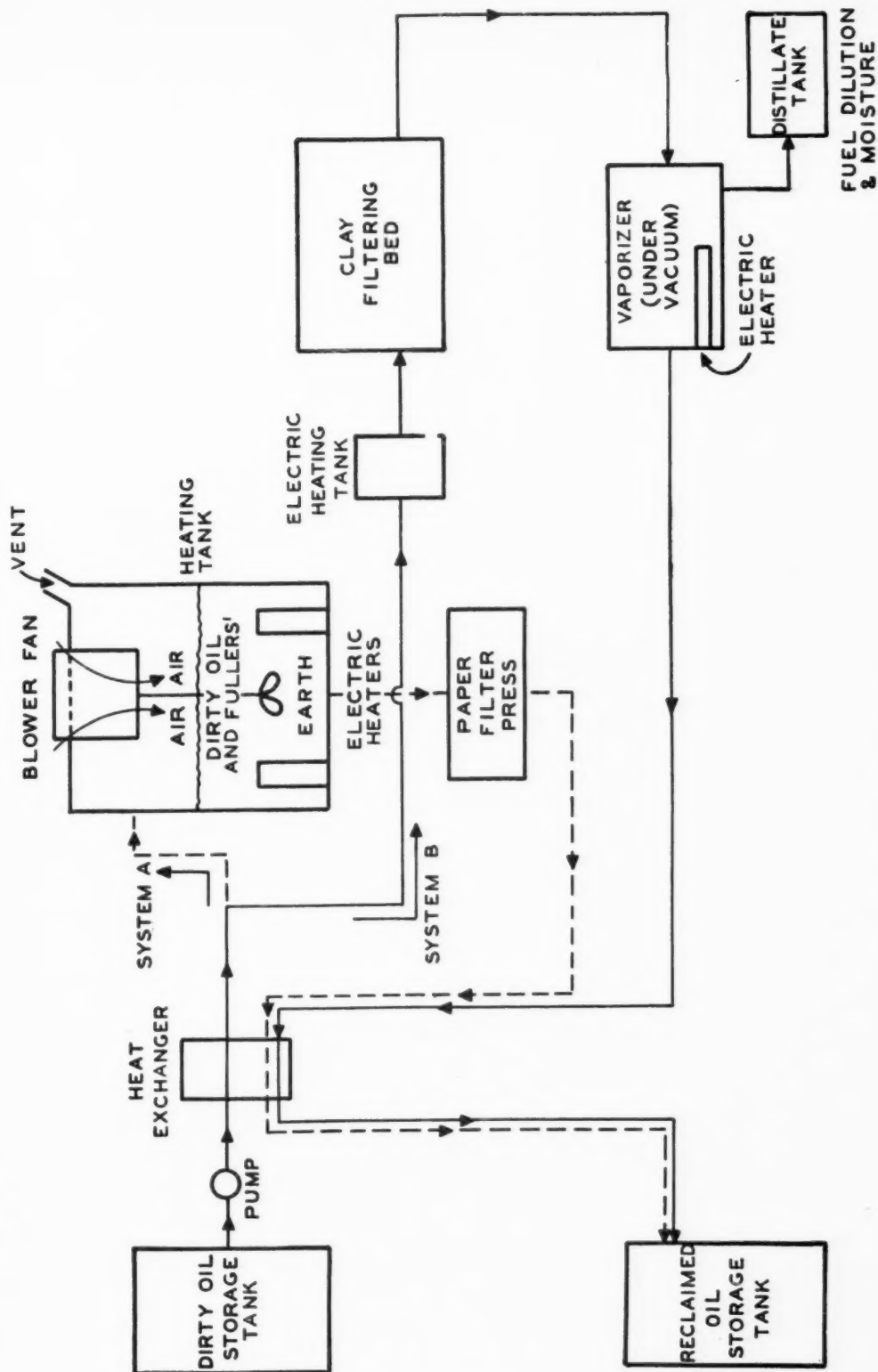


Courtesy of Honan-Crane Corporation

Figure 8—Cut-away view of a 24 cartridge Honan-Crane Type "M" continuous oil purifier. Each cartridge of a multiple cartridge unit handles an equal volume of oil.

STEPS IN NORMAL RECLAIMING OF USED OILS

LUBRICATION



3. More highly skilled personnel are required to properly handle reclaiming of used oil than are necessary for changing oil.
4. The reclaiming process cannot be applied to oils containing additives unless use can be found for the reclaimed oil in applications where the presence of additives is unnecessary.

Reclaiming of Oil by Chemical Treatment

The reclaiming of oil by chemical treatment is generally carried out in connection with clay treatment by either of the following methods:

1. Treatment with alkaline or caustic solutions.
2. Acid treatment followed by caustic or clay neutralization.

As these two chemical treatments are both used in the refining of new oil, it is to be expected that better reclaimed products can be produced than from other methods of oil purification and reclaiming. The procedures, however, are much more complex and trained personnel are required. Also, experimentation is generally required to determine suitable operating conditions for the treatments.

Due to the complex nature of these two processes, it is impossible to outline definite procedures to be followed. Wide variations exist in the type and condition of used lubricants to be handled, and the proper treatment of particular batches of oil must be considered individually to obtain best results. Since additive materials are removed by these processes, they should never be used for the reclaiming of additive oils unless use can be found for the reclaimed oil where presence of additives is unnecessary.

Treatment with Alkaline or Caustic Solutions

Generally the oil is heated to about 150° F. and mixed thoroughly with 10% alkaline solution for a considerable period of time in order to get satisfactory contact. Following this, the mixture is allowed to settle and the caustic solution and solids are drawn off at the tank bottom. The oil is then washed with water until the water appears clear when it is drawn off. To insure thorough washing, the wash water should be tested with an indicator and washing continued until the water drawn off is essentially neutral. Following the washing the oil is either filtered or centrifuged to remove the last traces of water. Sometimes it is necessary to filter the oil through adsorbent clay or to redistill the oil to remove organic soaps which are oil soluble. Partial or complete distillation is necessary if products of dilution are to be removed.

Treatment with Acid Followed by Caustic or Clay Neutralization

The oil is allowed to rest in a storage tank to promote settling of insoluble matter. The settled oil is then mixed with acid (dilute sulfuric acid normally about 10%) at a suitable temperature and the acid sludge is settled and drawn off. Further treatment is necessary to remove the last traces of acidic components. If these materials are inorganic in nature, clay treatment alone will generally remove them. If organic acids are present in appreciable amounts, it may be necessary to caustic wash the oil to convert them into soaps, which can be removed by subsequent clay filtration. After clay treatment, some method of separating the clay from the oil, such as filtering, must be employed.

Using this procedure oil may be treated with acid in a single or in several steps. Multiple step treatment is preferred because temperatures are more easily controlled and any water present in the oil is removed by the first batch of acid and thus does not dilute the subsequent acid batches thereby impairing their reclaiming powers. When multiple step treatment is used, the acid sludge is drawn off before each acid addition.

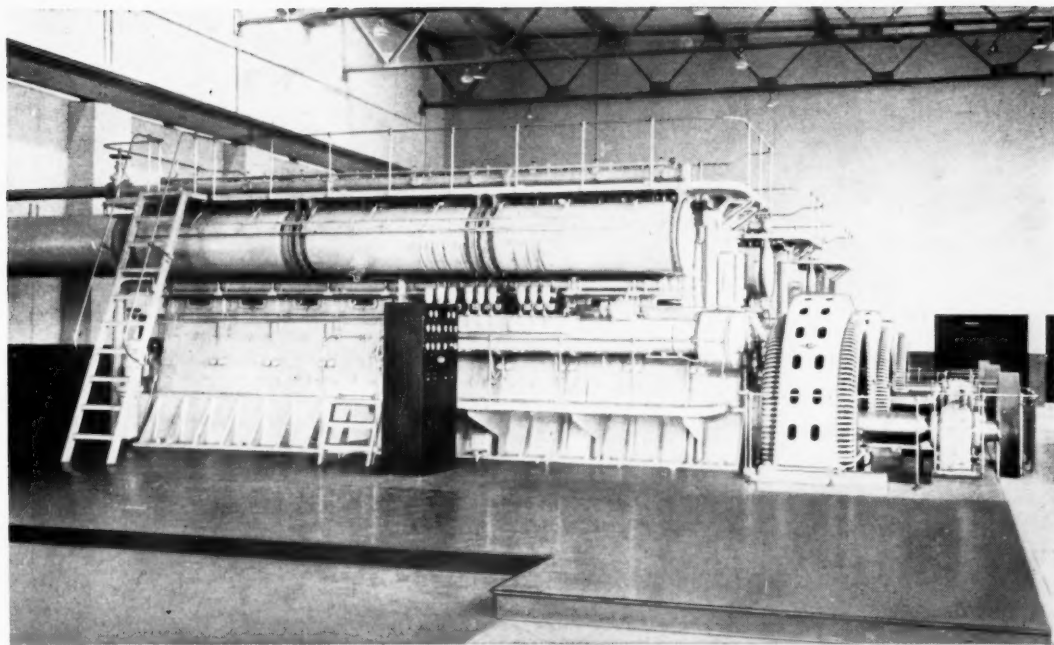
Some of the disadvantages to reclaiming used oils through chemical treatment are:

1. Treatment has to be carried out by personnel well acquainted with the subject under the supervision of qualified technicians.
2. Experimentation is necessary to determine the proper concentration of acid and temperature of operation to give best results.
3. Emulsion troubles may be encountered, especially with heavy oils, highly oxidized oils, or those containing additives.
4. Treatment losses are usually high.
5. Process is uneconomical unless carried out on large volumes of oil.
6. Additives are removed from heavy-duty oils.

Chemical treatment of used lubricating oil is perhaps the best method for reclaiming when proper equipment and suitable personnel are available.

CONCLUSION

A most important consideration, and one which must not be overlooked when selecting a method for extending the useful life of an oil, is that the oil after purification, filtration or reclamation must still be able to satisfactorily perform the function for which the new oil was designed and recommended. A close check by laboratory inspection, or established routine of operation, should therefore be maintained, once it has been established that a selected method of procedure will give satisfactory performance.



HOW TO PICK A WINNER

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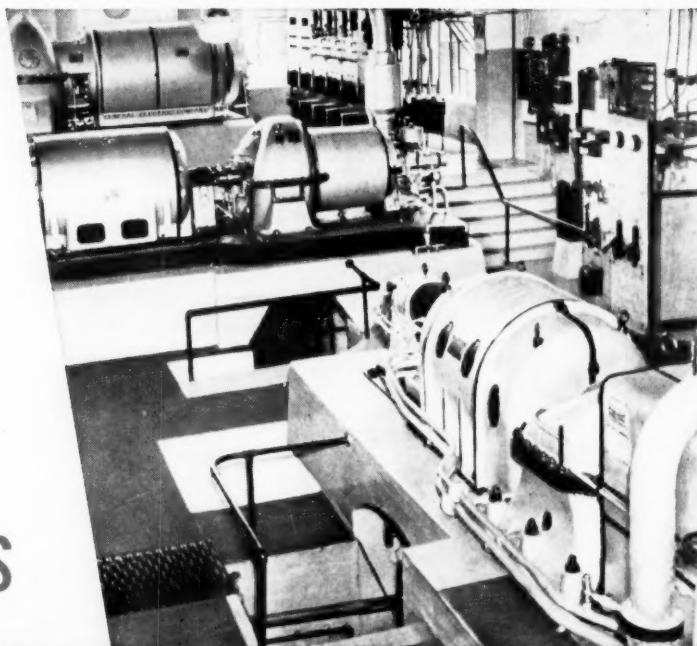
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